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**LIFE CYCLE ASSESSMENT AS A
MANAGEMENT TOOL**

by

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LIFE CYCLE ASSESSMENT AS A MANAGEMENT TOOL

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Introduction

Life Cycle Assessment (LCA) is potentially one of the most instructive management tools for gaining insight into product-related environmental impacts. It is considered by many as a complementary and more comprehensive tool with respect to other environmental management systems (EMS) for supporting an effective integration of environmental aspects in business and economy. However, strong opinion discrepancies still do exist among analysts about the practical use of LCA in business: "...LCA is the environmental management tool of the 1990s..." LCA will be seen as an integral part of the environmental tool-kit" (Jensen et al. 1997, p.28), "LCA procedures are too expensive and complicated, they could be only seldom be used" (Arnold 1993), "...many methodological choices are required and a number of aspects still need to be worked out, potentially jeopardizing the credibility of the outcome of LCA studies. This may lead to a decreasing confidence in and use of LCA by industry and governmental institutions." (Wrisberg et al. 1997). What is certain is that, despite still existing problems and barriers, the methodology and "technique" of LCA has significantly improved during the last years. Consensus does now exist on a large number of key issues, and several ISO norms have been published. The adoption of LCA in business has grown along these processes and LCA is used in many industry sectors now.

The objective of this chapter is to describe the current state-of the art of the use of LCA as a management tool and the outlook for the future. It focuses on the possible uses of LCA, the dynamic and learning aspects of LCA adoption patterns, and the current level of diffusion in the European Industry. Finally, it discusses the issues still to be overcome and the main recommendations for a future proper and increasingly widespread use of LCA in management within the framework of Industrial Ecology.

Main uses and current level of application

LCA can be used in many different ways in companies and several classification methods have been proposed in literature. Berkhout 1996 and Smith et al. 1998 link the uses to the position of the company in the product chain. So do Jensen et al. 1997, who also specify the level of detail in LCA (conceptual, simplified, detailed) related to each use. In general the criteria mainly used in literature to classify LCA applications distinguish between internal and external uses with respect to the firm (The

Nordic Council 1992, FTU/VITO/IÖW 1995, Smith et al 1998, Frankl & Rubik 2000)¹. Frankl & Rubik further suggest that uses can be classified along the product development chain and can either be retrospective, e.g. giving just a picture of the existing situation, or prospective, leading to innovation and systematic use (Frankl & Rubik 2000, p.32). The latter distinction is discussed in more detail in the next paragraph within the dynamic aspects of LCA introduction and integration patterns in companies. Table 1 summarizes the main possible uses of LCA in companies.

Internal uses

A recent survey conducted on almost 400 companies in Germany, Italy, Sweden and Switzerland shows that so far LCA is mostly used for internal purposes (Frankl & Rubik 2000, p. 72). This is substantially confirmed also by other studies carried out in Nordic European Countries (Hanssen 1999) and in Denmark (Broberg and Christensen 1999).

The identification of bottlenecks, i.e. of environmental critical points along the product life-cycle is by far the current most application of LCA in industry. This is not surprising since this is the first step in all kind of analysis, either retrospective or prospective.

The second most important internal application is the comparison of existing products with planned alternatives (Frankl & Rubik 2000). This still not always implies that the results will be actually implemented for product innovation. However in many companies already today LCA is used for Research, Design & Development, in particular in Nordic Countries. Hanssen refers that 32% of the almost 350 LCA studies reported in recent years in these countries are devoted to product development and improvement. It is clear that Nordic Countries are presently among the most pro-active countries with respect to a systematic use of LCA for environmental product innovation and improvement.

In principle, LCA is also very suitable to support long-term strategic decisions. Indeed it is very desirable that environmental assessment tools are used as early as possible in the product development process, as this can significantly reduce costs. On the other hand however, "for more complicated products the number of alternative possibilities is very high, and as the database on exotic materials is limited, the application of quantitative and detailed LCAs to such products may prove to be very resource demanding and at the same time not very precise" (Jensen et al 1997). As a matter of fact, Frankl & Rubik report that by 1998 only very few companies had used LCA for radical changes in the product life cycle and/or to shift from products to services (Frankl & Rubik 2000). However, the use of LCA for strategy development is expected to increase significantly in the future, as the knowledge on LCA methodology, the internal know-how and data, and the availability of public data-base improve. Conceptual or simplified

¹ The distinction is referred to whether the results of the LCA are just used internally in the firm or if they are communicated in some form to external subjects

LCAs are also likely to be used instead of long and costly detailed complete LCAs. Hanssen refers that already today 13% of LCA studies in Nordic Countries (25% in Finland) are intended for strategy development (Hanssen 1999).

External uses

In the past, especially in Germany, there have been great expectations concerning the use of LCA for marketing. However, even if this had provided the first motivation for starting LCA, in many cases companies quickly had to realize that LCA cannot be used for marketing at the current level of LCA methodology and availability and quality of data (Frankl & Rubik 2000 p.255). A similar result is reported for Denmark by (Broberg and Christensen 1999). There were several cases in the past in which competitors comparing the same kind of products came to opposite conclusions. Of course, in the eyes of consumers, disputable results have low credibility, and might also threaten the credibility of the whole methodology.

Basically, the main problem is about credibility and complexity of the results. In many cases in the past there has been a lack of transparency on several crucial aspects of any LCA study, such as sources and quality of data, the many assumptions needed (e.g. system boundaries, allocation rules, energy mix, etc.), the impact assessment method used, subjective valuation factors and procedures, and/or simplification procedures. Very clearly, by changing those factors, the result of an LCA study can be changed radically. The most crucial point has usually been the availability and quality of data. Unfortunately, in particular in the early 90s, there have been several cases of misuse of LCA with this specific respect, leading to completely wrong conclusions (Ayres 1994). As clearly stated by Jensen et al. "...This problem, coupled with biased information and lack of quality control, can do more than anything else to undermine the authority of LCA methods" (Jensen et al. 1999). The second problem is about complexity, i.e. how to summarize in a simple manner and very concise form a large and complex amount of data, information and assumptions. This issue holds even if the execution and the results of an LCA are as transparent as possible. These two set of problems have strongly limited the use of LCA for external purposes and have also likely been the most important threat to the credibility of the methodology so far.

Having correctly mentioned this, it is however important to observe that there have been very significant improvements with this specific respect in the very last years. The ISO norms 14040 and 14041 set now very precise rules for the external communication of LCA results, in particular in the case of product comparison (ISO 1996, ISO 1997). Companies are exploring several possibilities to communicate LCA results and obtain a market return in some form. Research institutions and policy-makers are participating in this process as well. As far as this is concerned, particularly interesting seem to be the tool of Environmental Product Declarations (EPD) and their use within the policy framework of Integrated Product

Policy (IPP) currently being developed in the European Union. Very clearly, an external use of LCA is expected to significantly increase in the future.

Already today, LCA is used to inform and influence suppliers, industrial clients and other stakeholders. The already mentioned survey carried out in Germany, Italy, Sweden and Switzerland shows that the use to provide generic information and education to customers and stakeholders is the second most important application of LCA (Frankl & Rubik 2000, p. 72). This great interest in external communication is also confirmed by Hanssen 1999 for the Nordic Region and Broberg & Christensen 1999 for Denmark.

LCA Adoption Patterns in the Firm

Different analysis approaches

Several studies have been focused on the integration of LCA in decision-making processes in recent years (Baumann 1998, Berkhout 1996, Frankl & Rubik 2000, FTU/VITO/IÖW 1995, Hanssen 1999, Smith et al 1998).

Berkhout and Smith et al. link important aspects of LCA integration in decision-making processes (i.e. orientation of life cycle activities, study practitioners and structure, adoption process, etc.) to the specific position of the company within the product chain, i.e. whether it produces commodity products, intermediate and simple products, or complex products. For instance, according to these authors, commodity producers mainly use LCA for external purposes (e.g. marketing, policy process), do not use evaluation methods and have a top-down adoption process. At the other extreme, the manufacturers of complex products use LCA for internal decision-support, use some evaluation method and have a bottom-up approach. However, this analysis approach is quite limited by the fact that it gives a static picture of the adoption of LCA in different sectors but at a given time.

On the contrary, Baumann, Frankl & Rubik point out that the adoption patterns of LCA in decision-making processes are a dynamic sequence of events which imply a learning process and cycles causing significant organizational challenges and changes within the firm. This implies that the role of LCA, the management tools and organizational structures adopted do vary with time and cannot be simply analyzed in a static way. Furthermore they stress the role and importance of subjective factors in this kind of evolution.

From learning to doing: the institutionalization theory

The institutionalization theory describes the characteristics of the different phases of the introduction of a new phenomenon (a new idea, a new instrument, an innovation in general) into business activities until it becomes something taken for granted and a routine use. This process is called “institutionalization” using the terms of organization theory (for more details ref. To Tolbert & Zucker 1996). The theory envisages three stages of the institutionalization process. The first stage of application of an innovation within the company is called habitualization stage. Often it concerns a small part or a restricted area of the company (e.g. most likely the environmental department in the case of LCA). The next stage, i.e. the one during which the new idea or tool begins to spread out within the company is called the objectification or semi-institutionalization stage. This is very likely the most crucial phase of the whole process. It is usually at this stage that the future adoption of the innovative idea or tool is determined. If the innovation is further systematically integrated within business activities, one enters the final stage of the full-institutionalization process, called the sedimentation stage in the original theory.

Frankl & Rubik have applied the theoretical framework of institutionalization to interpret the results of 20 case-studies carried out in Germany, Italy, Sweden and Switzerland in several industry sectors (Frankl & Rubik 2000). Furthermore more recently Frankl has applied the same theory to 16 studied companies in the energy sector in France, Germany, Italy, the Netherlands, Sweden and the United Kingdom (Frankl 2000). Figure 1 summarizes the results of the case-studies by showing the position of the studied companies along the institutionalization adoption curve. The latter represents the level of adoption of LCA within a company in function of time.

In principle, four possible trajectories of adoption pattern are possible. The upper continuous line in the figure shows an adoption curve leading to the full integration of the innovation (LCA in this case) within the company. The intermitted line represents the case of “uncertain companies”, in which the “destiny” of the innovation is still unclear. In these companies there are both positive indications which suggest for a further integration of the innovation as well as some negative signals which might indicate a possible future failure. The two other possible (negative) adoption paths - dotted in figure - are leading to an early failure or to a the late fading out of the innovation. As already mentioned earlier and shown in the figure, the crucial phase is the one of semi-institutionalization, during which the “destiny” of the innovation is most likely determined.

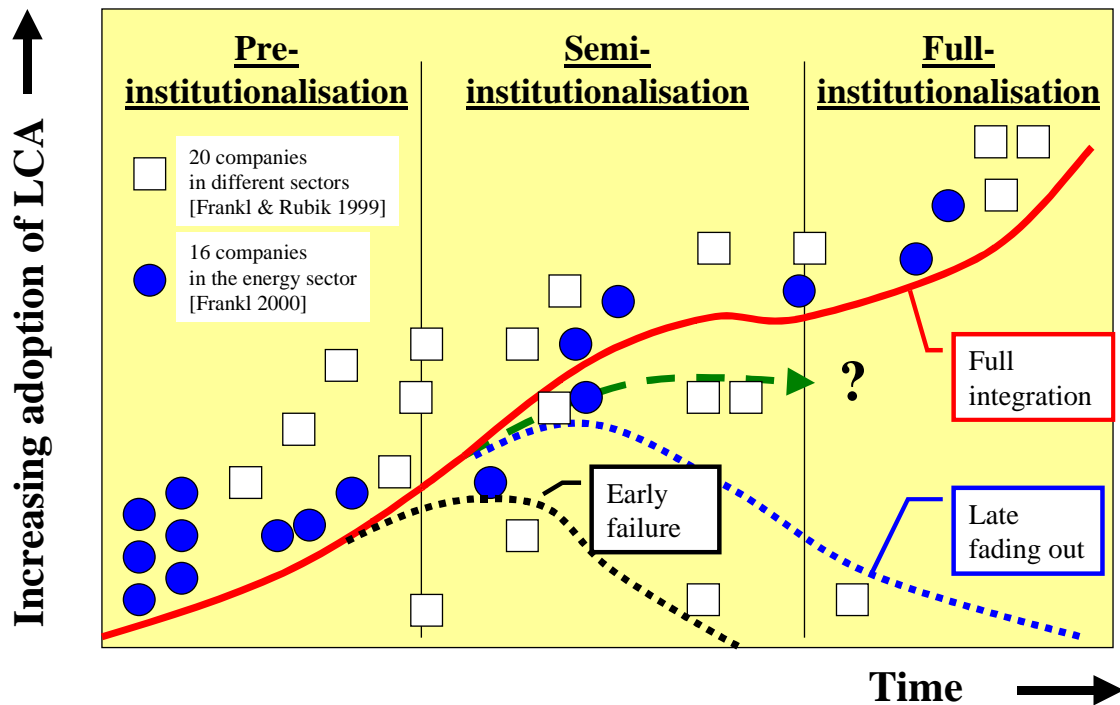


Fig.1 - Possible adoption patterns of LCA according to institutionalization theory and positioning of 36 surveyed companies by 1998

The first result to be observed is that by 1998 just 5 companies of the 36 surveyed had fully integrated LCA into their decision-making processes. This basically confirms the results reported also by other authors, that LCA is still a young methodology and that "...companies have simply not, by and large, felt the need for LCA in their regular decision-making" (Jensen et al. 1997 p.14). However, the dynamic analysis approach of case-studies and institutionalization theory also clearly indicates that this situation is rapidly changing. As a matter of fact, the 8 companies in the semi-institutionalization phase are clearly going towards full institutionalization in the next future. Moreover, the large majority of firms still at the introduction phase also declared that they will increase the level of LCA activities. In another survey recently carried out in Denmark, 18 companies over 26 declared that they would base their future product development on LCA studies (Broberg and Christensen 1999).

Success factors for full institutionalization and the role of LCA

A dynamic analysis approach also allows to identify the main success factors for full institutionalization of LCA or the factors for failure. There are several main factors influencing the institutionalization of LCA in business decision-making processes (Frankl & Rubik 2000). I recall here the main ones. Among the others, I wish to highlight the importance of the actors and subjective factors - in

particular the presence and influence of a “champion” (or “entrepreneur”), who pushes LCA activities within the company. Other key factors are the mandate of top-management, the involvement of practitioners and development of formalized structures, the establishment of internal communication channels, the development of internal know-how, and a long-term environmental commitment.

No particular success factors are needed in the first pre-institutionalization stage. As a matter of fact it has been observed that the introduction of LCA can happen both by a top-down approach (i.e. through the indications of top-management) or bottom-up (e.g. by the initiative of an environmental manager, without any mandate of top management at this stage). This does not influence the future adoption of LCA.

On the contrary, the mandate of top-management becomes an important factor within the second mid-institutionalization stage. At that point, the top-management has to be informed about LCA activities and has to agree with their further development.

The motivation and involvement of practitioners is important in all three stages. It might be important already in the first stage of pre-institutionalization if the introduction of LCA happens bottom-up. It certainly becomes important in the two next stages, as the number of functions and people involved in LCA increases (i.e. when other technical departments are involved).

However, the most likely important factor for the success of the whole institutionalization process is the presence and influence of a personally committed “entrepreneur” or “champion”, who pushes LCA activities within the firm. His role is particularly crucial in the mid- institutionalization stage: it is him who elaborates the strategy to demonstrate the importance of LCA and create a consensus around it (in particular to obtain the mandate of top-management). It is still him who has the task of maintaining the mandate of top-management and enlarging the consensus basis (by promoting advocacy groups and motivating/involving a larger set of champions) during the last stage of full- institutionalization. Advocacy groups might not be involved directly in LCA activities, but they support them from outside.

Another crucial factor for spreading out the consensus and the involvement of people in LCA and thus leading to full- institutionalization, is the existence of appropriate (usually inter-department) communication channels. Without them, the message of the champion can be hardly be spread out and a large set of champions be created. This is not important in the first stage, but it becomes increasingly important in the second stage and strictly necessary in the third one of full-institutionalization. These communication channels can be created either at the beginning (e.g. with a coordination committee for LCA including representatives of different departments) or later on in time (e.g. at FIAT Auto with the “Integrated Development Plan of Car Components”).

Moreover, the development of internal know-how (both in terms of dedicated human resources, data-base and software tools) on the method and application of LCA seems to be necessary to achieve

full-institutionalization. It has been observed that no company relying only on external support has continued LCA activities in the long-term. Of course, the importance of internal know-how increases with time and the institutionalization stage. Formal structures (i.e. with full-time dedicated functions) are always observed in companies in the full- institutionalization stage. The latter two results are confirmed also in Denmark (Broberg and Christensen 1999).

Finally, a long-term environmental commitment seems to be a necessary (although not sufficient) condition for the full adoption and integration of LCA. It was observed, that in all successful cases of LCA integration a clear long-term environmental policy was present in the company.

Quite obviously, the role of LCA changes along the different institutionalization stages. At the beginning, it is always just for learning. The application of LCA is rather retrospective, i.e. for confirmation of already known results. In the mid-institutionalization stage LCA still has a high learning value, but there is a shift from retrospective application towards more prospective uses, i.e. LCA is used for designing new products or new alternatives. In the full-institutionalization stage LCA becomes a quasi-routine tool. The learning value is consequently much lower. Uses can be very different (internal, external), but tend to be precise. The application tends to be prospective: LCA is used for design choices. In the best-cases it is used for every-day decision-making support.

As far as the translation into practice of LCA results is concerned, it has to be observed that the application of LCA influences both short-term and long-term product innovations. This is related to how learning is translated into action. Usually short-term innovations are determined by economic factors (changes indicated by LCA are adopted only if they provide economic gains as well). Of course, short-term innovations are important in particular in the full-institutionalization stage. However, companies are much more open to long-term product innovations. For instance, LCA results can influence, also from the very beginning of the institutionalization process, strategic decisions (i.e. the next cycle of investments).

At present, the most certain and likely highest value of LCA is learning. In all these companies where a learning process occurred, it also implied: A change and development in internal organization, several spin-off initiatives (i.e. energy and material saving, bottleneck identification, supply-chain management, etc.), a collaborative attitude tending to compare its experience with the one of other companies and/or research institutes, the goal of using LCA in a systematic way in the future as a support tool for decision-making, eventually using simplification methods, learning and higher motivation of employees (Frankl & Rubik 2000). The value and importance of learning is also highlighted by (Broberg and Christensen 1999), who indicate that in many cases the work on LCA actually results in new priorities in companies.

Outlook

General observations

The general outlook concerning the future use of LCA as a management tool is very positive. Already today, LCA is diffused in most industry sectors in Europe, US and Japan, other Asian Countries, and also in Australia. European Countries and Japan are clearly at the forefront of the methodology and its application in industry. Germany has currently the largest absolute number of LCA studies, but Sweden has the highest number per GDP². LCA activities are increasing very rapidly and significantly in Japan, where there is an important National LCA project (Hunkeler et al. 1999, Finkbeiner and Matsuno 2000). The large majority of surveyed companies declared that the LCA use will increase in the future, eventually in combination with other tools (Frankl & Rubik 2000, p. 82). There is a clear shift from a rather retrospective use towards a more prospective use leading to product innovation and systematic use as decision-making support tool. Moreover, an increased use for external communication is expected (see next sub-sections).

Open issues and possible solutions

The likely most important issue of LCA today is still the availability and quality of data. In particular, this might be an insurmountable barrier for Small and Medium Enterprises (SMEs), which do neither have financial nor human resources to achieve these data. As far as quality is concerned, crucial points are usually the lack of transparency, management of missing data, sufficient separation of data and flexibility and openness of the data-base (and/or LCA software tool). A very significant contribution for the solution of this problem can be given by the development of public shared data-base at National and international level on some specific parts of life cycle which are common to practically all products, i.e. energy systems, transportation, waste management and production of bulk materials. This is exactly what is happening in several countries in Europe, Japan and Korea (Frankl 2000, Hunkeler et al. 1999). A second very important progress is the systematic use of verification by an external peer review, as indicated by the ISO norms. Of course, the latter has to be done at a high level of excellence³. In any case, as mentioned by (Wrisberg et al, 1997) the transparency and credibility can be significantly enhanced by involving stakeholders in external/public LCA studies as early as possible.

A second issue is related to impact assessment and indicators. A very significant progress has been achieved in the very last years concerning this topic, and the assessment of local impacts in

² Most LCA studies are not published. A systematic updated inventory of LCA studies does not exist. Frankl & Rubik 2000 refer about almost 300 studies by the end of 1997 in Germany. However, (Saur 2000) estimates that the number of LCA studies by May 2000 is well over 500. Hanssen 1999 reports almost 350 LCA studies carried out in Nordic Countries.

particular. Nevertheless, the problems still remains that the weighting of single impact categories is and will always be a subjective procedure, depending on local and human factors. With this respect it is worth mentioning the possibility of using other tools, i.e. multi-criteria analysis, for the interpretation of LCA results (e.g. in Hirschberg & Dones 1998 for Energy Systems). I consider this kind of model and approach as an extremely important example of how LCA can be used for decision-making. The very positive aspect is that it combines different indicators in order to arrive at a final evaluation, but without reducing everything to a single unit of measurement (money or "points"). Instead, it reflects the complexity of reality and takes into account the importance of subjective valuations. The assumptions are completely transparent; the system is fully flexible and all needed sensitivity analyses can be performed. The other advantage is that it can include not only environmental aspects but also health, risk assessment, social and economic factors for the final evaluation (see further discussion in next sub-sections).

Asking the right question – The link with other management tools

The right question is not whether LCA will become the ultimate environmental assessment method of products and services taking all possible effects and impacts into account. To me, the right question is: is LCA, or under which conditions will it be, a valuable support tool for management? This is the real question concerning the decision-makers, at any level, either in business or in the public administration.

My answer to this question is clearly yes. To my opinion, despite all the complexity and still existing problems, LCA is already now a very valuable support tool, given that some key requirements (maximum of transparency, flexibility and openness of the model) are satisfied. However, it should be very clear, that LCA cannot and will never be able to substitute the decision-maker himself. LCA simply quantifies the complexity of reality. The high value of LCA as a support tool for decision-making is that it gives a strategic system view although considering the technological details, it has an enormous learning value, and it reduces the number of parameters in function of which decisions have to be taken.

As far as this is concerned, the link with other (environmental and not) management tools is of paramount importance. So far, there has not been a biunivocal correspondence between LCA and other Environmental Management Systems (EMS) such as ISO 14000 and/or EMAS: the existence and/or planning of an EMS seems a necessary, but not sufficient condition to carry out an LCA (Frankl & Rubik 2000, p.59). In specific countries, the relation between LCA and other EMS is particularly weak (Broberg & Christensen 1999). Rightly so, since those EMS were strongly focusing on the organization or the site only. However, the positive relation with LCA is expected to strongly increase in the future: The EMAS II regulation explicitly focuses on the life-cycle of products and services.

³ With this specific respect, it is worth mentioning that SETAC-Europe is going to organize a case-study workshop called "Increasing Credibility of LCA" in November 2000, where all the problems and difficulties related to peer reviews and

From a product to a system approach – The role of LCA for Industrial Ecology

So far, LCA has been mostly used for the environmental assessment of products. In the last years, it also has been used to assess services, which is a first step towards the applicability of LCA for eco-efficiency. However, the real large and ultimate potential is the network approach to environmental problems typical of Industrial Ecology. This requires a paradigm shift from a product approach towards a system approach. Moreover, it implies a shift towards the assessment of sustainability, that is including also social and economic factors, and not just the environmental impacts. This means that innovative assessment and communication methods and tools have to be developed in order to address different stakeholders at the same time. In particular these tools have to be able to reflect the value of sustainability in market terms (e.g. to financial stakeholders and/or consumers). This process has barely begun, but it represents in my view the most important potential of LCA as a management tool.

The importance of effective communication

In such a network approach effective, different and specific assessment and communication instruments are needed. Different tools have to be used for different target stakeholders.. I wish to report here the model proposed by (Hanssen 1999). In his view, life-cycle data have to be managed in specific environmental accounting systems, in a similar manner in which economic data are treated today. "From these databases, the companies can communicate information internally and externally through Environmental Performance Indicators with focus on organizations, and through Environmental Product Declarations with focus on specific products" (Hanssen 1999). As already mentioned, the latter, based on life-cycle, third-party verified quantified information is rapidly gaining interest in several Countries. In 1999, The Swedish Environmental Management Council has created an EPD logo and fixed the criteria for companies to obtain the label. This is expected to happen also in Italy at the beginning of 2001. EPD is currently object of a standardization process (Technical Report ISO-TR 14025).

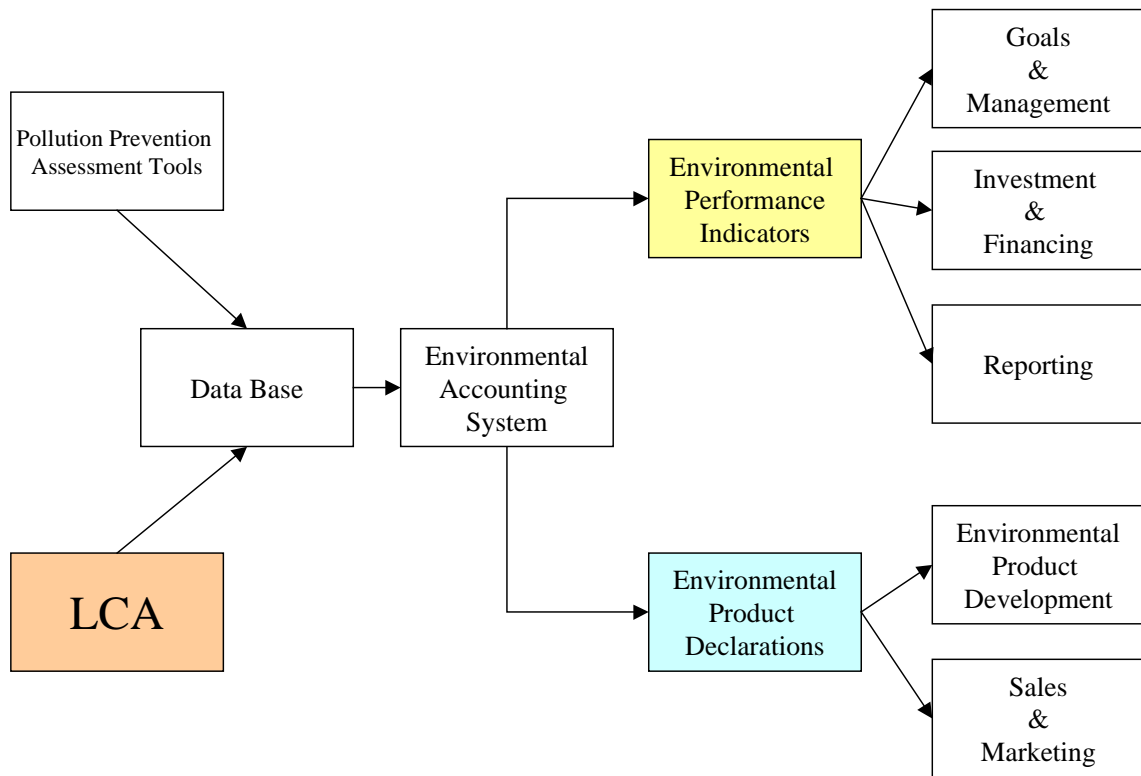


Fig. 2 Possible life-cycle based management tool-kit and communication flows (source: Hanssen 1999)

The proposed model precisely allows to involve different stakeholder with different tools. Of course, several other models are currently being proposed as well. For instance, in the EPD of its cars, Volvo combines information about the product and the organization, notably on environmental management (Volvo Cars 2000)⁴. With this respect I also wish to mention a research project I am currently participating in called “DEEP – Developing Effective Environmental Product Information Schemes”⁵. All the proposed models have in common that they follow a multi-stakeholder approach.

A multi-stakeholder approach – Success Factor for the future diffusion of LCA

Not only a multi-stakeholder seems to be a necessary approach to implement the mentioned shift from a product approach to the system approach of Industrial Ecology. In the particular case of LCA, I think that multi-stakeholder approaches might play a crucial role as success factor for the future diffusion of LCA in any case. I see several reasons for this. As mentioned several times, LCA still has a set of important open issues, i.e. availability and quality of data, methods for impact assessment, simplification and screening procedures etc. Even large companies feel the need to exchange and compare their

⁴ Volvo has been one of the first companies worldwide to present an EPD of its product (based on LCA) through internet

experience with other companies and research institutions. If there is a place where this interaction can happen, this turns out to be a very important factor for the success of LCA. In fact, there is an example of this kind in Sweden, i.e. the Centre for Environmental Assessment of Product and Material Systems (CPM) at Chalmers Institute of Technology in Gothenborg. This centre has been collecting all the experiences on LCA from different sources (companies, research centres, universities, etc.). It is a reference organism for all LCA practitioners in Sweden, and has played and plays a crucial role for the diffusion of LCA in that country⁶. Similarly, it is worth mentioning that National Associations of LCA have been founded in recent years in Japan, Korea⁷, India and Italy, which include representatives from industry, universities and research institutions, NGOs, consumer organizations, as well as public authorities⁸.

Summarizing, I think that multi-stakeholder organizations might play a crucial role for the future diffusion of LCA with respect to:

- Availability and quality of data (either peer reviewing or commissioning shared data-bases;
- Impact assessment methods (defining guidelines with respect to indicators to be used and methods to evaluate the different impacts - i.e. multi-criteria analysis);
- Developing standardized simplification and screening procedures;
- Increasing the dialogue between business and legislators, thus facilitating business to anticipate legislation;
- Developing methods to combine LCA with other management tools for decision-making support;
- Exploring ways for using LCA for environmental declarations of products, third-party certified eco-labeling and/or environmental product information schemes in general, within the policy framework of IPP;
- And last but not least to foster the education of consumers, who shall play an increasingly important (and potentially crucial) role with respect to more sustainable consumption and Industrial Ecology.

I am strongly convinced that creating a permanent dialogue channel between all the involved subjects (in particular between suppliers, regulators and consumers) and sharing responsibility is of crucial importance for the future diffusion of LCA and its growing integration within the framework of Industrial Ecology.

⁵ The research is funded by the European Commission DG XII, and is carried out by the IÖW (Heidelberg, Germany), the University of Rome - Dip.to ITACA Sezione Ambiente, SIFO (Lysaker, Norway), and RANDA Group (Barcelona, Spain)

⁶ I wish to remind that Sweden has currently the highest number of LCA studies per GDP

⁷ For more details, see (Hur 1999)

⁸ Also in France, there is an initiative to create a French Association for LCA, basing on the positive experience of RECORD (focusing only on waste management).

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